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Optical Systems Study

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NASA
Headquarters
Washington 25, D. C.

ATTN: Mr. Roland H. Chase, Technical Director
Code RET

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Subject: MIROS Progress Letter No. 10
(NASA Contract NASw-703)

Dear Mr. Chase:

This letter is a statement of progress made on the MIROS program during the period extending from February 20, 1964 to March 20, 1964. This period covered the fifth month of the experimental program phase.

Work Accomplished

During this period the mercury cell experiment was completed and the set up dismantled. Some of the experimental results are shown below for comparison with theory. It will be seen that agreement between theory and experiment is good.

Modulation transfer has so far not been achieved in the alkali halide crystals. This is not unreasonable because of the necessity of doing extensive preliminary experimental work because of lack of information on potassium iodide crystals. It has been necessary, for instance, to determine in which spectral regions the F and F^1 absorption bands of potassium iodide are located. This in itself is a long and tedius process since the crystals must be handled in darkness and with provision for cooling to at least liquid nitrogen temperature if any reliable and comprehensive information is to be obtained. Most of our efforts have therefore been expended obtaining this type of data. Additional time loss occurs because almost each new experiment must be performed with a new colored crystal since exposure to light of wavelengths other than in F & F^1 bands causes other impurity centers to become populated. This of course mitigates the usefulness of any further experimental results obtained from this particular crystal. It is consequently, necessary to diffuse a new crystal for each new set of runs. Much of the pertinent data on potassium iodide has been accumulated as of this report, so expectations are that success will shortly be reported.

Mercury Cell Experiment

The mercury cell modulation transfer scheme has fulfilled all expectations and it can be averred that this experiment was concluded successfully. The following are some of the experimental results compared with theory.

It was stated in the last report that absorption of the 4047 Å line should vary nearly linearly with the intensity of the 2537 Å lamp. The exact formula is

$$\frac{A_{31}}{k_{4047}} \ln \frac{I_{4047}}{I^{o}_{4047}} + = I^{o}_{4047} - k_{2537}\, I_{2537}\, l, \text{ where}$$

A_{31} is the inverse lifetime for transitions from ^3P_o to ground,

k_{4047} is the absorption coefficient in units of $\frac{cm^{-1}}{atom/cc}$,

I^{o}_{4047} is the initial intensity in photons/cm^2-sec of the 4047 Å line,

I_{4047} is the intensity of the 4047 line after traversing a length l of the absorption cell,

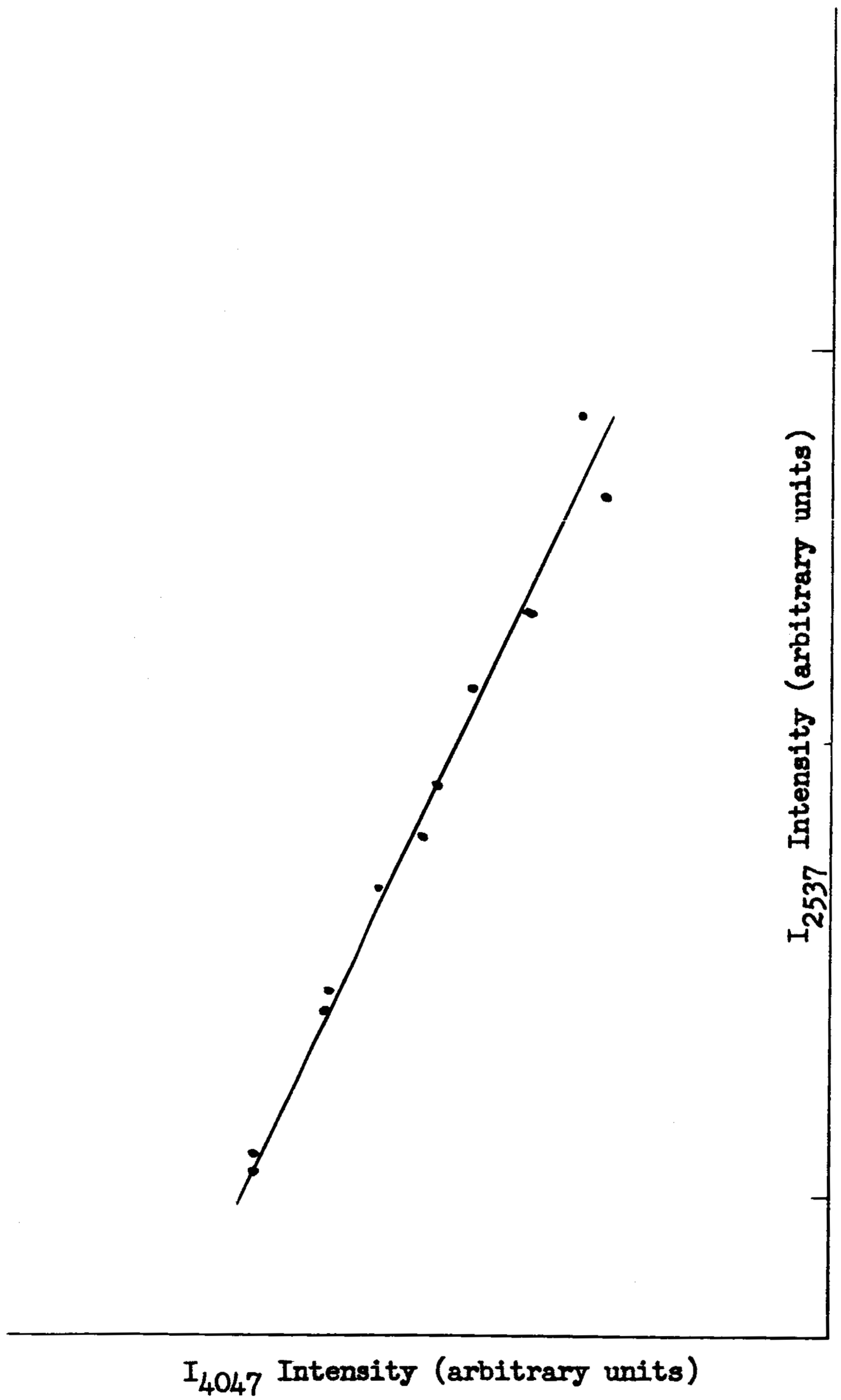
k_{2537} is the absorption coefficient in cm^{-1} of the 2537 Å line and,

I_{2537} is the intensity in photons/cm^2-sec of the 2537 Å line.

If it is noted that A_{31} is a comparatively small number, transitions from $^3P_0$ to ground being almost forbidden, the term involving this quantity can be neglected and the resulting equation is seen to be linear. Evidently, doubling the cell length, or doubling I_{2537} give equivalent results.

In order to test this theory it was decided to modulate the 2537Å lamp intensity and monitor a small amount of the output from this lamp. In this way it was possible to plot I_{4047} VS. I_{2537}. The result is shown in figure 1.

In order to obtain this plot, it was necessary to monitor the 2537 Å lamp, not directly but by measuring the intensity of light from this lamp after being scattered by an auxilliary absorption cell. The reason for this is that when the 2537 Å lamp is driven harder it becomes hotter, with consequent broadening and self reversal of the resonance line, hence, even though the lamp becomes brighter, the power in the narrow spectral region around the 2537 Å line center may actually decrease. Since it is only this narrow spectral region that is absorbed by the modulation transfer cell, it is evident that induced absorption will not necessarily increase with lamp intensity. Several runs were made monitoring the 2537 Å lamp directly and it was found that, while for small powers from the 2537 Å source the induced modulation was nearly linear, the slope of the line decreased with increased 2537 Å power. The situation was improved considerably by cooling the 2537 Å lamp with an air jet, but it was felt that a reliable estimate of absorbed 2537 Å power could be obtained only by measuring the power



Experimentally determined graph showing the linear dependence of absorption on I_{2537} intensity

Figure 1

contained in a narrow spectral region around the 2537 Å line. Since the photomultiplier was insensitive to such spectral broadening, the use of an auxilliary absorption cell was the best solution. Of course, the modulation transfer cell could not be monitored because any 2537 Å flourescence was quenched by the nitrogen.

The frequency response the cell was calculated and found to a good approximation to follow the equation

$$I_{4047}\ (w) = \frac{A_{23}\ k_{2537}\ I_{2537}\ l}{2\sqrt{A^2_{23} + w^2}}$$

where A_{23} represents the number of $^3P_1 \longrightarrow {}^3P_o$ transitions per second,

w is the frequency, and the other terms have already been defined.

In the case of the mercury cell, the parameter A_{23} depends on nitrogen pressure. It can be seen for example that the .707 frequency is at around 70 KC for 2mm N_2 pressure. When the experiment was performed it was found that the frequency response remained almost flat out to about 2 KC, then began to drop off. Taking into account limitations in the set-up, agreement with theory appears to be satisfactory here.

Finally, an estimate of the rise time of the system was derived. Theory indicated this to follow very nearly the formula;

$$I_{4047} = I^o{}_{4047} + k_{2537}\ I_{2537}\ l\ \left[e^{-A_{23}\ t} - 1 \right]$$

Note that for l = 0, no modulation ever occurs.

Again the parameter A_{23} plays the critical role in the response time of the system. When this equation was compared with experimental results, there was good agreement.

Visits

A visit was made by NASA officials, Dr. Harry Plotkin and Mr. R. H. Chase to Westinghouse in order to discuss progress on the MIROS project. Westinghouse persons attending the meeting were Mssrs. C. Kline and J. Goodell. Mr. Goodell presented a review of efforts and accomplishments on the MIROS project. This was followed by discussion of the possibilities of realizing a practical MIROS element. Both the alkali halide and gas cell schemes were discussed with respect to power requirements as well as applicability to existing laser sources. It was unanimously concluded that, now that passive modulation transfer has been shown to be possible, some comparison with active or semi-active schemes should be made in order to determine relative feasibilities of the two approaches. Both experiments were shown to Dr. Plotkin and Mr. Chase.

Plans For Next Period

During the next period work will continue on the alkali halide experiment. Results of the mercury cell experiment will be sorted, examined and prepared for the final report. Efforts will also be expended on some of the other MIROS schemes which have so far received secondary consideration.

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